

ALOHATM and ARCHIE: A Comparison

Mary Evans

Modeling and Simulation Studies Branch
Hazardous Materials Response and Assessment
Division
Office of Ocean Resources Conservation and
Assessment
National Oceanic and Atmospheric Administration
Seattle, Washington 98115

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Note

Areal Locations of Hazardous Atmospheres (ALOHA™) and Automated Resource for Chemical Hazard Evaluation (ARCHIE) are dynamic models that will continue to be refined over time. The discussion presented in this document refers to ALOHA version 5.1 and ARCHIE version 1.0.

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Chapter 1

ALOHATM and ARCHIE: A Comparison

Introduction

Areal Locations of Hazardous Atmospheres (ALOHATM) and Automated Resource for Chemical Hazard Incident Evaluation (ARCHIE) are publicly available air dispersion models primarily intended for use by emergency response personnel. ALOHA was jointly produced by the National Oceanic and Atmospheric Administration's Hazardous Materials Response and Assessment Division and the U. S. Environmental Protection Agency's (EPA) Chemical Emergency Preparedness and Prevention Office. ARCHIE was produced by Hazmat America, Inc., and has been approved for distribution by the Federal Emergency Management Agency (FEMA), the U. S. Department of Transportation (DOT), and EPA.

ALOHA currently runs either on Macintosh microcomputers or in Microsoft WindowsTM on IBM-compatible microcomputers. ALOHA is available for \$215 to government and non-profit agencies and \$610 to commercial institutions. Registered users may obtain program upgrades as well as free user support via telephone, quarterly newsletter, or electronic bulletin board. ARCHIE runs in the MS-DOS operating system on IBM-compatible microcomputers. It is available for free from FEMA, DOT, or EPA. Free user support is available via electronic bulletin board.

Both models allow users to enter information about a chemical and the circumstances of an accidental spill, and will estimate the extent of downwind dispersion of the chemical. Principal differences between the models include the following points:

- ARCHIE models fire and explosion hazards (but not shrapnel hazards) as well as air dispersion; ALOHA models only air dispersion of volatile chemicals.

- ALOHA includes a heavy gas dispersion model; ARCHIE does not.
- ALOHA plots “footprints” of dispersing chemical clouds on a grid; footprints can also be plotted on a background map in the MARPLOT™ (either on a Macintosh or in DOS) or BitPlot (in Windows) mapping applications. ALOHA provides other output in both text and graphic form. ARCHIE provides text tables as output.
- Along with tables of ground-level and source height centerline concentrations downwind of a spill source, ARCHIE outputs tables of arrival and departure times for dispersing chemicals. ALOHA footprints reflect ground-level concentrations only. ALOHA users may view graphs of predicted concentration over time for specific locations.
- ALOHA allows users to choose among a variety of units when entering information into the model; ARCHIE allows a choice of units for only a few required input values.
- ALOHA includes a chemical properties library with more than 700 entries. Complete information needed to run the model is included for about half of these entries; partial information is available for the remaining entries. Users may add new chemicals and property information to ALOHA’s chemical library. ARCHIE does not include a chemical library. However, users may store property information in ARCHIE in advance of a spill by preparing and archiving accident scenario files which include necessary chemical property information.
- ALOHA includes a library of U.S. cities, including elevation, latitude and longitude, and time zone information required by the model. Users may make additions or modifications to the city library. ARCHIE does not include a library of locations (and does not account for location when making computations).

- ALOHA accounts for indoor air infiltration when computing concentration and dose estimates for locations chosen by the user; ARCHIE does not.

Features included in the two models are shown in Table 1, below. Source and dispersion algorithms included in the two models are compared in Table 2. Inputs required to evaluate the types of accidental releases modeled by both ALOHA and ARCHIE are shown in Table 3.

System Requirements

ALOHA

ALOHA runs on any Apple Macintosh computer with at least one megabyte of random access memory (RAM) and a hard drive. At least 2 megabytes of hard disk space must be available to load ALOHA for the Macintosh. It also runs in either Standard or Enhanced mode in Microsoft Windows, version 3.0 or above. In Windows, ALOHA requires at least 1 megabyte of RAM and about 2.5 megabytes of hard disk space. A 80386 or above microprocessor is recommended for ALOHA. A math coprocessor chip is recommended but not required for either version of ALOHA.

ARCHIE

ARCHIE runs on IBM personal computers and compatible computers that operate under either the PC-DOS or MS-DOS operating systems, versions 2.0 or later. The model requires a hard drive or two disk drives. ARCHIE requires about 500 kilobytes of disk space, 512 kilobytes of RAM, and either a monochrome or color 80-column monitor linked to any of several display adapters.

Table 1.
Features included in ALOHA and ARCHIE

Model includes/accounts for:	ALOHA	ARCHIE
<i>Data Handling</i>		
Chemical library		
City library		
Data collected by portable weather station		
Accident scenario archiving†		
Choice of units for all inputs		
<i>Source Strength</i>		
User entry of release rate		
Pressurized liquid tank		
Non-pressurized liquid tank		
Pressurized gas tank		
Pressurized liquid pipeline		
Pressurized gas pipeline		
Stand-alone non-boiling puddle		
Stand-alone boiling puddle		
<i>Vapor Dispersion</i>		
Choice of roughness lengths		
Above-ground source heights		
Effects of inversion		
Neutral gas driver		
Heavy gas driver		
Indoor air infiltration		
Concentration at specific location		
Dose at specific location††		
<i>Fire and Explosion Hazards</i>		
Liquid pool fires		
Flame jets		
Fireball thermal radiation		
Vapor cloud fires		
Vapor cloud explosions		
Tank overpressurization explosions		
Condensed-phase explosions		
<i>Type of Output</i>		
Text summary		
Text tables		
Graphs		
Footprint plotted on grid or map		

† ALOHA allows users to save all scenario output as archived files. Such files can be viewed, but cannot be used as model input. The model also allows users to save some scenario information, such as location and chemical information and tank, diked area, and pipe dimensions for use in additional modeling. ARCHIE users may store all model inputs and outputs in archive files for future modeling use.

†† ALOHA allows users to choose a dose exponent.

Table 2.
Source and dispersion algorithms
in ALOHA and ARCHIE

ALOHA	ARCHIE
<i>Unpressurized liquid release from tank</i>	
Leak can be from any height on tank	Leak is at tank bottom
Tank leaks until liquid level falls below hole bottom	Tank leaks until empty
Uses constant hole discharge coefficient†	User can enter value for discharge coefficient
<i>Pressurized liquid release from tank</i>	
Accounts for evaporative cooling in tank	Does not account for cooling
Accounts for air ingestion during release	Does not account for ingestion
Liquid remains in tank if hole not at bottom	All chemical released
Release rate can change over time	Entire release at peak rate
<i>Pressurized gas release from tank</i>	
Accounts for tank pressure effect on rate	Entire release at peak rate
<i>Non-boiling puddle evaporation</i>	
Solar radiation affects evaporation rate	Does not account for solar radiation
Ground and air temperature affects rate	Accounts for air temperature only
Evaporation rate can vary over time	Assumes constant evaporation rate
<i>Boiling puddle evaporation</i>	
Accounts for evaporative cooling	Does not account for cooling
Heat transfer from ground and air affects rate	Uses correlation of boiling and burning rates
Evaporation rate can vary over time	Assumes constant evaporation rate
<i>Gas pipeline release</i>	
Models release from pipe connected to large source	Does not account for connection to large source
Models release from pipe of finite length	Models release from pipe of finite length
Release rate can change over time	Entire release at 75% of initial peak rate
<i>Liquid pipeline release</i>	
Does not model liquid pipeline releases††	Models liquid pipeline releases
<i>Gas dispersion</i>	
Accounts for ground roughness	Does not account for ground roughness
Includes heavy gas model	All gases assumed neutrally buoyant
Accounts for indoor air infiltration	Does not account for air infiltration
Reports dose for user-specified locations	Does not report dose
<i>Fire and explosion hazards</i>	
Does not model fire and explosion hazards	Models fire and explosion hazards

† The discharge coefficient is a measure of the characteristics of the edges of the rupture that affect release rate. Generally, the more jagged the edges, the more impeded the flow.

†† Releases from liquid pipelines up to 1000 m in length can be modeled via ALOHA's tank source option.

Table 3.
Information required by ALOHA and ARCHIE to compute source strength estimates for tank and gas pipeline releases, and to calculate downwind dispersion of an escaping chemical†

REQUIRED INFORMATION	ALOHA	ARCHIE
<i>Meteorology and site data</i>		
Time of day		
Date		
Elevation		
Latitude and longitude		
Building type or infiltration rate		
Stability class		
Air temperature		
Wind speed		
Roughness length or class		
Cloud cover		
Relative humidity		
<i>Liquid tank release</i>		
Chemical name	††	
Molecular weight	††	
Normal boiling point	††	
Critical pressure	††	
Critical temperature	††	
Normal freezing point	††	
Heat capacity (gas, const. press.)	††	
Heat capacity (liquid, const. press.)	††	
Liquid specific gravity		
Vapor pressure		
Mass, volume, or height of liquid		
Tank dimensions		
Tank temperature		
Hole type and dimensions		
Discharge coefficient of hole		
Hole location on tank wall		
Ground type (unpressurized liquid)		
Ground temperature (unpress. liq.)		
Diked area (unpress. liq.)		

† Chemical property information is required by ALOHA only if the information is not available in the ALOHA chemical library. Latitude, longitude, and elevation information is maintained in the ALOHA city library.

†† These values, if not already present in the chemical library, may be entered by the user.

Table 3, *cont.*

REQUIRED INFORMATION	ALOHA	ARCHIE
<i>Gas tank release</i>		
Chemical name	††	
Molecular weight	††	
Normal boiling point	††	
Critical pressure	††	
Critical temperature	††	
Normal freezing point	††	
Heat capacity (gas, const. press.)	††	
Heat capacity (liquid, const. press.)	††	
Mass of gas or tank pressure		
Tank dimensions		
Tank temperature		
Hole type and dimensions		
Discharge coefficient of hole		
Ratio of specific heats for the gas		
<i>Gas pipeline release</i>		
Chemical name	††	
Molecular weight	††	
Normal boiling point	††	
Critical pressure	††	
Critical temperature	††	
Heat capacity (gas, const. press.)	††	
Pipe temperature		
Pipe length and diameter		
Connected to large source or closed-off		
Hole area		
Discharge coefficient of hole		
Pipe pressure		
Rough or smooth wall surface		
Vapor pressure in pipeline		
Ratio of specific heats for the gas		
<i>Gas dispersion</i>		
Chemical name	NG/HG	
Molecular weight	NG/HG	
Normal boiling point	HG	
Gas density	HG	
Gas heat capacity	HG	
Crit. temp. (or vapor press.)	HG	
Crit. press. (or vapor press.)	HG	
Vapor pressure		
Level of concern/Toxic threshold	NG/HG	
Release height	NG	

NG = Neutral gas dispersion

HG = Heavy gas dispersion

††These values, if not already present in the chemical library, may be entered by the user.

Chapter 2

ALOHA and ARCHIE: Calculation Methods

ALOHA and ARCHIE use a variety of calculation methods to make source strength and dispersion predictions in toxic gas release cases.

The models differ in several fundamental aspects. First, unlike ALOHA, ARCHIE predicts fire and explosion risks (but does not predict shrapnel hazard) from liquid pool fires, flame jets, fireball thermal radiation, vapor cloud fires, unconfined vapor cloud explosions, tank overpressurization explosions, and condensed-phase explosions. Second, unlike ARCHIE, ALOHA's calculations of release rates take into account factors that affect the rate of the release over time, such as evaporative cooling within a tank or puddle. Third, ALOHA also incorporates two dispersion models, one to calculate dispersion of neutrally buoyant gases, and another to model dispersion of "heavy gases," denser-than-air vapor clouds. ARCHIE does not have a heavy gas model.

For more detailed information about ALOHA's source strength and dispersion calculations, refer to the ALOHA technical documentation (Reynolds 1992). Detailed descriptions of ARCHIE's source and dispersion equations are appended to the user handbook (Federal Emergency Management Agency et al. 1988).

Source Strength Calculations

Inputs

ALOHA predicts rate and duration of a release from information stored in the ALOHA chemical library about the chemical of concern and from user-entered values. This information can include tank, pipe, or puddle size, amount of chemical, tank or pipe pressure, weather conditions, and temperature.

ARCHIE predicts rate and duration of release from information entered by the user. Although ARCHIE does not have a chemical library, users may pre-store accident scenario files, which may include chemical property data, tank dimensions, storage amounts, and other pertinent information.

Time Dependence

ALOHA produces each source strength estimate as a series of up to 100 time steps. An instantaneous release rate is calculated for each time step. Generally, each step lasts long enough for one percent of the potential mass of the pollutant to be released to the atmosphere. These 100 steps are then averaged down into a series of five or fewer time steps, which is then sent to one of ALOHA's two dispersion modules. Each of these five steps must last at least one minute. Because in most cases, meteorological conditions are expected to change substantially from one hour to the next, ALOHA expects that the total release duration will never exceed one hour. If a release continues for more than an hour, users are encouraged to rerun the model, using adjusted meteorological information.

ARCHIE's source strength estimates are not time-dependent. That is, the model predicts release rates that do not change over time. ARCHIE either calculates a peak or an average rate of release, depending on the type of release, for a given scenario, then calculates the amount of time necessary to release all potential mass of the pollutant at that release rate.

Non-Pressurized Liquid Tank Release Cases

ALOHA

ALOHA predicts that a chemical will flow as a pure liquid from a tank whenever its vapor pressure is below atmospheric pressure (whenever storage temperature is below the boiling point). Any pure liquid release is expected to be driven by gravitational head and by its own vapor pressure exerted within the tank. If the liquid level is above the tank hole, ALOHA allows for the ingestion of a small amount of air. This ingestion of air is insurance against a complete cessation of flow when the total tank pressure approaches atmospheric pressure. The model expects flow to stop once the liquid level has dropped to the level of the bottom of the tank hole or leaking valve. The liquid will change temperature due to evaporation within the tank and heat exchange through the tank walls. The hole may be at any height on the tank wall. The cross-sectional area of the flowing liquid depends on whether the liquid surface intersects the hole.

In any non-pressurized liquid release case, ALOHA expects a puddle to form on the ground below the tank. If the user does not enter a value for maximum puddle diameter (as would be appropriate if the tank were diked), ALOHA expects the puddle to spread either until evaporation rate and spreading rate are balanced or until the puddle has reached a minimum average depth of 0.5 cm. ALOHA calculates puddle spread rate as a function of puddle mass, liquid density, and gravity.

In non-cryogenic puddle cases, liquid spills from a tank to form a puddle that is cooler than its boiling point. ALOHA calculates evaporation rates for such cases depending primarily on puddle temperature and, hence, on heat flux between the puddle and its environment. The puddle temperature is expected to change over time (although in most cases, it reaches a steady-state value). ALOHA accounts for five energy flux terms—solar radiation, longwave radiation, ground heat exchange, sensible heat, and evaporative energy loss—when computing the evaporation rate from a puddle.

If a liquid has been stored below its boiling point, but ambient ground and air temperatures exceed its boiling point, a cryogenic, or boiling, puddle will form when the liquid leaks from a tank. In such cases, ALOHA expects the puddle temperature to remain at the boiling point and the vapor pressure to remain equal to the atmospheric pressure. The model expects evaporative flux to be balanced mainly by heat input from the ground, although the other energy flux terms described above are also computed. ALOHA also accounts for cooling of the ground beneath a cryogenic puddle.

In cases of both cryogenic and non-cryogenic puddles formed by liquid that is continuously leaking from a tank, ALOHA accounts for the effects of changing leak rate and puddle radius on the evaporation rate.

ARCHIE

ARCHIE assumes that a leak is at the tank bottom in all cases. ARCHIE calculates an average spill rate, then calculates the amount of time necessary to empty the tank if flow continues at that rate. Gravitational head drives flow from the tank, with a puddle expected to form.

When the user does not enter a value for maximum pool diameter, ARCHIE first calculates a value for evaporation or vaporization rate per unit area. The model then calculates an equilibrium puddle area by assuming that spreading will continue until the total evaporation or vaporization rate equals the tank leak rate.

ARCHIE estimates of evaporation rates of non-boiling liquids and of liquids that boil at temperatures above 0°C are functions of wind speed, vapor pressure at ambient temperature, molecular weight, and pool temperature.

Estimates of evaporation rates of liquids that boil at temperatures below 0°C are made using a correlation between evaporation and burning rates¹ of liquids. This correlation was empirically derived from observations

¹ The burning rate of a flammable liquid is the rate at which the depth of a burning pool decreases over time.

made on a set of hazardous chemicals (Burgess et al. 1961). ARCHIE expects vaporization rates from cold boiling puddles to depend on the predicted burning rate of the liquid—estimated from its molecular weight, specific gravity, and boiling point—and on its liquid density.

Stand-alone Puddle Releases

Both ALOHA and ARCHIE can model evaporation from non-boiling, stand-alone puddles of fixed radius, using the puddle evaporation algorithms described above, without accounting for puddle spreading. Only ALOHA models evaporation from stand-alone boiling puddles. (The model uses the algorithm described above, but does not allow for puddle spreading). In stand-alone puddle cases, the user is asked to enter a value for puddle area, and a value for puddle depth, volume, or mass, in the case of ALOHA, or liquid weight, in the case of ARCHIE.

Two-Phase Tank Release Cases

ALOHA

ALOHA predicts that a chemical will flow from a tank as a two-phase release of vapor and aerosol whenever vapor pressure of a liquid stored in a tank is above atmospheric pressure (whenever the storage temperature exceeds boiling point). Any two-phase release is expected to be driven by the differential between tank pressure and atmospheric pressure and by hydrostatic pressure. ALOHA expects the release rate to slow as tank pressure drops and hydrostatic head is diminished. The model expects a release to stop once tank pressure has dropped to atmospheric and hydrostatic head has dropped to zero (i.e., the liquid level reaches the bottom of the hole, which may be located at any height on the tank wall). Predicted rate of release also is affected by size of the tank hole, but not by its discharge coefficient. ALOHA adjusts the rate of flow through a leaking pipe or valve downward to account for flashing flow through the restricted space.

In all two-phase release cases, any liquid present above the tank hole is expected to exit the tank as a mixture of gas and aerosol. The model expects all aerosol to evaporate before hitting the ground, so that no

puddle is formed. For computational simplicity, if the hole is at the bottom of the tank, ALOHA expects all initial mass to exit the tank, and ignores the amount of vapor that would actually remain once tank pressure reached 1 atmosphere (atm). When the hole is above the tank bottom, the model tracks both liquid and vapor mass remaining in the tank during and after a release. In these cases, the model expects a portion of the initial mass, representing vapor at 1 atm pressure, to remain in the tank at the completion of a release.

ALOHA calculates the rate of evaporation of liquid into the tank vapor space, and takes into account heat loss from evaporative cooling. It also takes into account heat exchange through the tank walls. The temperature within the tank is not allowed to drop below boiling, however.

ARCHIE

ARCHIE calculates the rate of flow of pressurized liquid from a tank as a function of rupture area, discharge coefficient of the tank hole, liquid density, and the differential between atmospheric and tank pressure. The model ignores the effect of gravitational head, which is expected to be less important than the tank pressure effect.

The model assumes in all cases that a hole or rupture is located at the bottom of the tank, and always predicts that all of the chemical (including vapor) will be released. If a release is through a short pipe at least 4 inches in length instead of through a simple tank hole, the model accounts for flashing two-phase flow within the pipe. ARCHIE assumes that whenever storage temperature exceeds boiling point by 6 K, a mixture of gas and aerosols will be released from the tank, and no liquid will pool on the ground. At temperatures lower than 6 K above boiling, the model predicts that a liquid pool will form.

ARCHIE calculates an instantaneous peak rate of release, then calculates the expected duration of release if all material is assumed to exit a tank at the peak rate. For this reason, ARCHIE does not take evaporative cooling

into account, and generally overpredicts release rate and underpredicts release duration.

Pure Gas Tank Releases

ALOHA

ALOHA expects the differential between tank pressure and atmospheric pressure to drive the rate of release of a pure gas from a tank. From the ratio of atmospheric to tank pressure, the ratio of hole width to tank length, and the critical pressure ratio for sonic flow (a threshold pressure ratio value), ALOHA first determines whether a gas flow will be supersonic (choked) or subsonic (unchoked). If the pressure difference is great enough, ALOHA models flow as supersonic until the pressure drops to the point at which flow is subsonic. At this point, ALOHA then calculates subsonic release rate until tank pressure drops to atmospheric. ALOHA-calculated rates of gas release drop over time because the tank pressure is expected to drop as gas exits the tank, and as adiabatic expansion cools tank contents. However, ALOHA does not account for the effect of heat flux across the tank wall, or for frictional differences between tank holes and short pipes/valves. In this case, the model will produce identical source strength predictions regardless of which rupture type users choose.

ARCHIE

ARCHIE also differentiates between supersonic and subsonic flow by comparing the ratio of tank to atmospheric pressure to the estimated critical pressure ratio. ARCHIE-calculated gas release rates are not time-dependent. The model first calculates the initial discharge rate of gas from a tank, then calculates the time required to empty the tank if material continues to exit at this rate. Thus, ARCHIE tends to overpredict release rate and underpredict release duration. Expansion cooling and pressure decline are not taken into account.

Gas Pipe Release Cases

ALOHA

ALOHA can model both (1) cases in which a container of very large capacity is attached to a gas pipe (the steady-state release case) or (2) cases in which a pipe of finite length is closed off at its unbroken end. In ALOHA, flow of gas through a pipe is expected to be isothermal, except for the last 200 pipe diameters. Isothermal flow is assumed to result from a balance between frictional heating and expansion cooling. Gas moving through the last section of pipe is expected to expand adiabatically. ALOHA calculates a friction factor to account for the roughness of the inside walls of the pipe, defined by the user as either “rough” or “smooth.” The rupture area may be any value greater than zero and up to the cross-sectional area of the pipe. Ruptures are expected to be located at the end of the pipeline.

Both in cases of connected and finite-length pipes, initial flow rate is modeled as choked flow, and as a function of initial pipe pressure and temperature, rupture area, and the specific heat ratio of the gas. This flow rate is used as the steady-state flow rate in cases of release from a pipeline connected to an infinitely large reservoir. Flow is expected to continue for one hour, the maximum time for any ALOHA-modeled release. In cases of releases from finite-length pipelines, release rate is expected to decline as pipe pressure drops.

ARCHIE

ARCHIE models only cases of gas release from pipelines of finite length that are unconnected to a reservoir. The user may specify whether a hole occurs in the line or whether a complete break occurs either at the end or at some point on the line. ARCHIE incorporates a model that treats a filled gas pipeline as a volume of compressed, non-flowing gas. It does not account for the effects of friction along the pipe, and hence does not differentiate among pipes of different roughnesses. The model produces an estimate of 75% of the peak release rate in cases of full line breaks, and the length of time needed to empty the pipeline at that rate of release. Model authors found that this volume model underpredicts blowdown

time and overpredicts release rate, hence producing a conservative estimate of downwind distance.

Dispersion Calculations

ALOHA

ALOHA incorporates two air dispersion models: a Gaussian model to predict the downwind dispersion of neutral and positively buoyant gases, and ALOHA-DEGADIS, a simplified version of the heavy gas model DEGADIS (Havens and Spicer 1985). Both models compute pollutant concentrations only at ground level, where a dispersing chemical is most likely to contact people, and produce a “footprint”, plotted either on a grid or background map. Each footprint represents the area within which, at some point during the hour following the beginning of a release, ground level pollutant concentrations will reach or exceed the level of concern entered by the user. Both models also produce graphs of indoor and outdoor concentration and dose expected to be experienced by people at any specific location identified by the user.

In all cases, ALOHA takes ground roughness into account. In heavy gas dispersion cases, it accounts for relative humidity, air temperature, and other influences on gas cloud development. Users may either select a dispersion module to use in evaluating a particular scenario, or allow ALOHA to select the most appropriate module, based on the friction Richardson’s number of the vapor cloud.

ALOHA’s Gaussian dispersion algorithm can account for a release rate that changes over time, as well as for trapping of dispersing vapor by low-level atmospheric inversions and by the ground. It can also account for an above-ground release, when the user directly enters a value for release rate of a chemical into the atmosphere. The dispersion parameters σ_y and σ_z , which describe the horizontal and vertical spread of each vapor cloud, are calculated either from the user’s estimate of the atmospheric stability class, or, when a portable weather station is being

used with the model, directly from measurements of variability in wind direction.

ALOHA's Gaussian model treats each release as a series of one to five short-duration releases of contaminant. Each individual release must last at least one minute; the total release duration must not exceed 60 minutes. Each of these release segments, or "clouds", disperses passively like a classic Gaussian plume, but with its leading and trailing edges diffusing upstream and downstream by turbulent mixing.

ALOHA-DEGADIS includes algorithms for prediction of downwind movement of heavy gases modified from those used by the DEGADIS dispersion model (Havens and Spicer 1985). A heavy gas cloud is expected by the model to disperse downwind in a more complex manner than a neutrally-buoyant cloud. Early in a heavy gas release, the dense vapor cloud is expected to slump away from the release point, rapidly becoming increasingly less dense by entraining air, and forming a secondary blanket centered on the release point. Further from the source, the cloud maintains its stable stratification, remaining low to the ground and resisting the effects of air turbulence as it moves downwind. Even further from the source, the cloud is expected to be so diluted by air that its further travel is modeled by ALOHA as passive dispersion.

When producing a footprint plot, to speed calculations, ALOHA-DEGADIS does not account for changing release rate. Instead, the model treats the largest release rate estimate from among the five time steps as a steady-state rate. Footprints from short-duration heavy gas releases hence can be overpredicted. When estimating ground-level concentration and dose at a location specified by the user, however, ALOHA's heavy gas and Gaussian dispersion models account for release rates that change over time. Time-dependent solutions are feasible in such cases because the heavy gas concentration and dose equations are solved for a single point only, rather than for a full grid of points as is necessary when producing a footprint plot.

ARCHIE

ARCHIE assumes that all gases are neutrally buoyant and will disperse passively downwind. The model does not take ground roughness or relative humidity into account when making dispersion calculations.

According to its documentation, the ARCHIE dispersion module incorporates some features of both Gaussian plume and puff dispersion models. The dispersion parameters σ_y and σ_z are calculated from the user's estimate of the atmospheric stability class. The model assumes that for short duration spills, lateral and longitudinal dispersion coefficients (σ_x and σ_y) are of equal magnitude.

ARCHIE produces a text table including ground level and source height concentrations at a series of downwind points along the centerline and evacuation zone widths at each point, a second table displaying contaminant arrival and departure times at each point in the series, and an estimate of the downwind distance to the level of concern set by the user.

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